

Parental care



Parental care

1. Costs and benefits of parental care
2. Sexual conflicts in parental care
3. Parent-offspring recognition
4. Parent-offspring conflicts

1.To care or not to care?

Costs and benefits of parental care

Produce more offspring with
less parental care, or

Produce less offspring with
more parental care?





More or less parental care ?



1.To care or not to care?

Care enhances offspring survival?
e.g., protection from predation

Limitation of food or other resources:
abundant food → less cost for care

Lifetime reproductive investment
parents tend to have more
offspring in their lifetime.

2. Why is parental care more often
maternal than paternal?

Female costs vs. benefits:

Females have already invested so much in producing eggs.

Females are sure of their genes will pass on.
Depending on offspring survival

Male costs vs. benefits:

Males tend to mate as many mates as possible,
invest more energy on attracting females

Males are not sure if their genes will pass on.
Depending on offspring survival

Male fishes are unusual that they often provide uni-parental care:

Why?



Stickleback

Male fishes are unusual that they often provide uni-parental care:

1. external fertilization
2. defend territory
3. ensure paternity



Randall's Jawfish



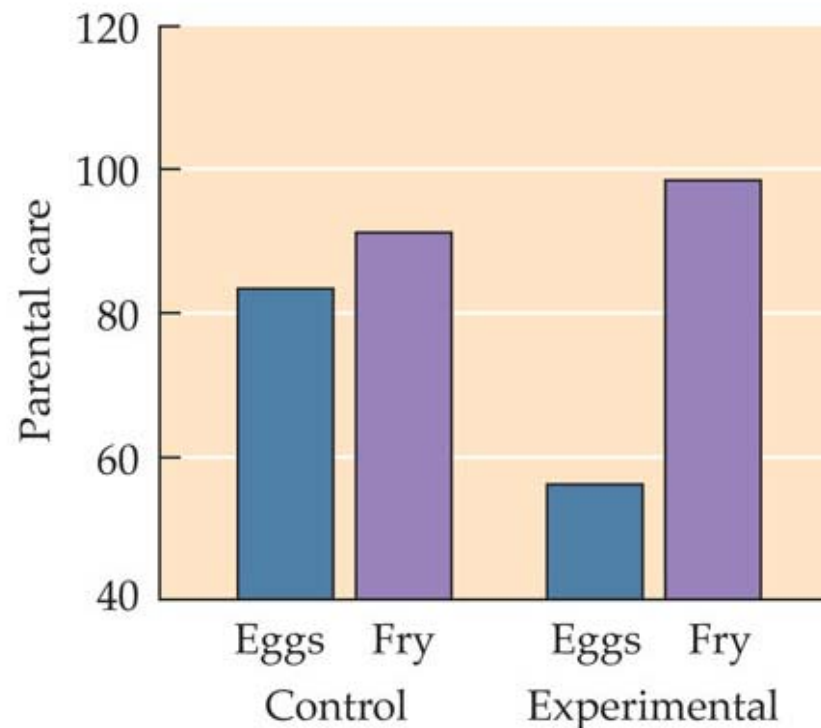
Stickleback

Paternal behavior might evolve when males can ensure paternity

Hypothesis: Males are more likely to take care of young if they “think” they’re the dad



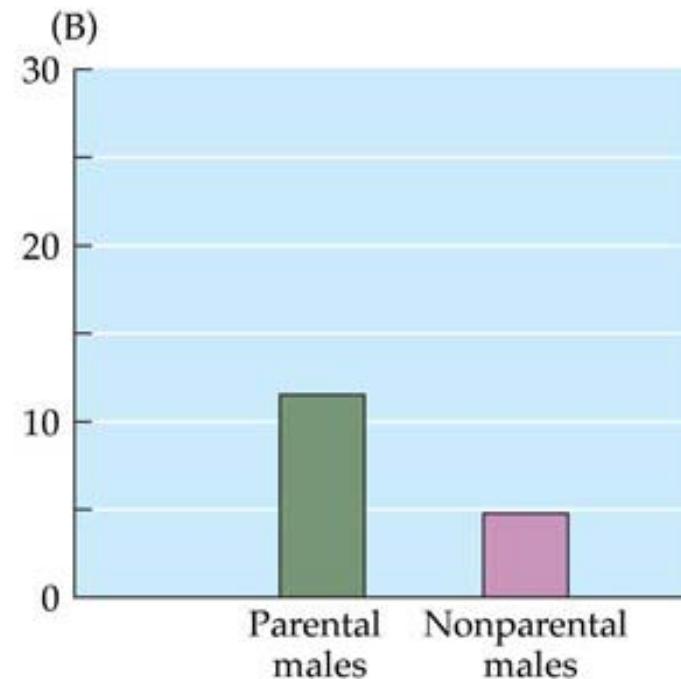
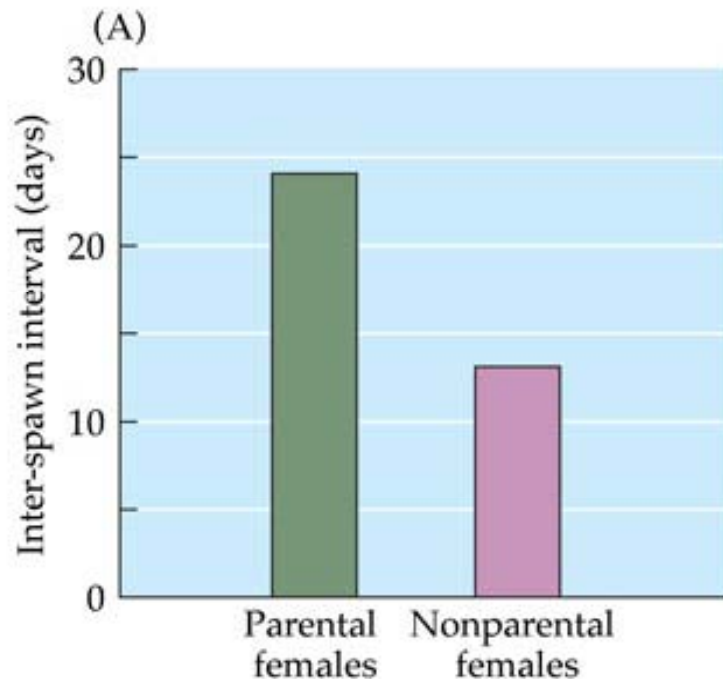
Bluegill



Experiments:

Temporarily remove the father fish during egg stage or fry stage....

Paternal behavior might evolve when costs are lower for males than for females



Article #1 The Pregnant Brain as a Revving Race Car

1. What kind of physiological changes occur when females are pregnant?
2. Mother has to have a brain that is highly sensitive to child's need.
3. Major brain changes in (a) mPOA: get ready to respond to child's need

-- quickly respond to the child.

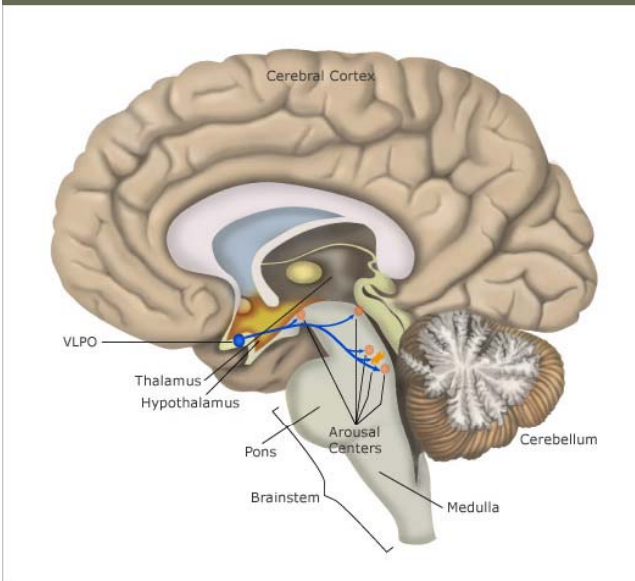
(b) hippocampus: increase dendrite density;
enhance learning/ memory

-- evolutionary advantage: locate food faster

(c) hormonal changes: more sensitive to
emotional changes; facial expression
-- more focus on their child.

(d) gazing: correlates with oxytocin

4. What is race-car-burning-rubber theory?



Article #2 Fatherhood leads to drop in testosterone

1. What is the relation between testosterone level and parental care?
2. Why do humans need bi-parental care?
3. Why do lower testosterone level is good for parenting?
4. Why do males with higher testosterone level tend to be the father, but once they become fathers, their testosterone drops? What is the evolutionary adaptation for this change?

3. Parent-offspring recognition



Many colonial species are good at offspring recognition

Parent-offspring recognition

Parents should avoid caring young that are not their own offspring.

But not all species identify their own progeny?

Mexican free-tailed bats

Pregnant females form colonies in the millions...

~4000 pups per square meters

Can mother bats nurse discriminately?



Offspring recognition: function to prevent misdirected parental care.

Prediction: Parents should be especially good at identifying their own young in colonial species (living in a social group) but not as well in solitary species.

Bank swallows and rough-winged swallows

Bank swallows: **colonial** species,
fledglings have distinctive
begging calls

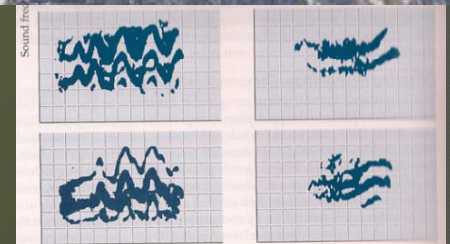


Rough-winged swallows:
solitary species: fledglings have,
less distinctive begging calls



Cliff swallows and barn swallows

Cliff swallows: **colonial** species;
nestlings have distinctive,
highly variable begging calls
Parents recognize their young.



Barn swallows: **solitary** species
fledglings have less distinctive calls
Parents do not recognize the young



Parent-offspring recognition

Parents should avoid caring young that are not their own offspring.

But not all species can identify their own offspring:

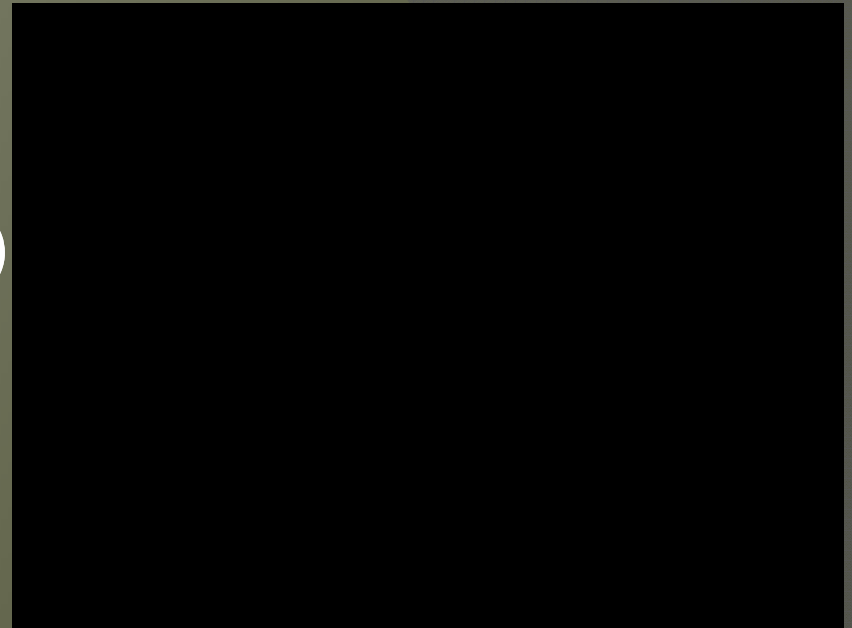
1. Many solitary/ territorial species
2. Species provide less/ no care

2. species provide less/ no care:

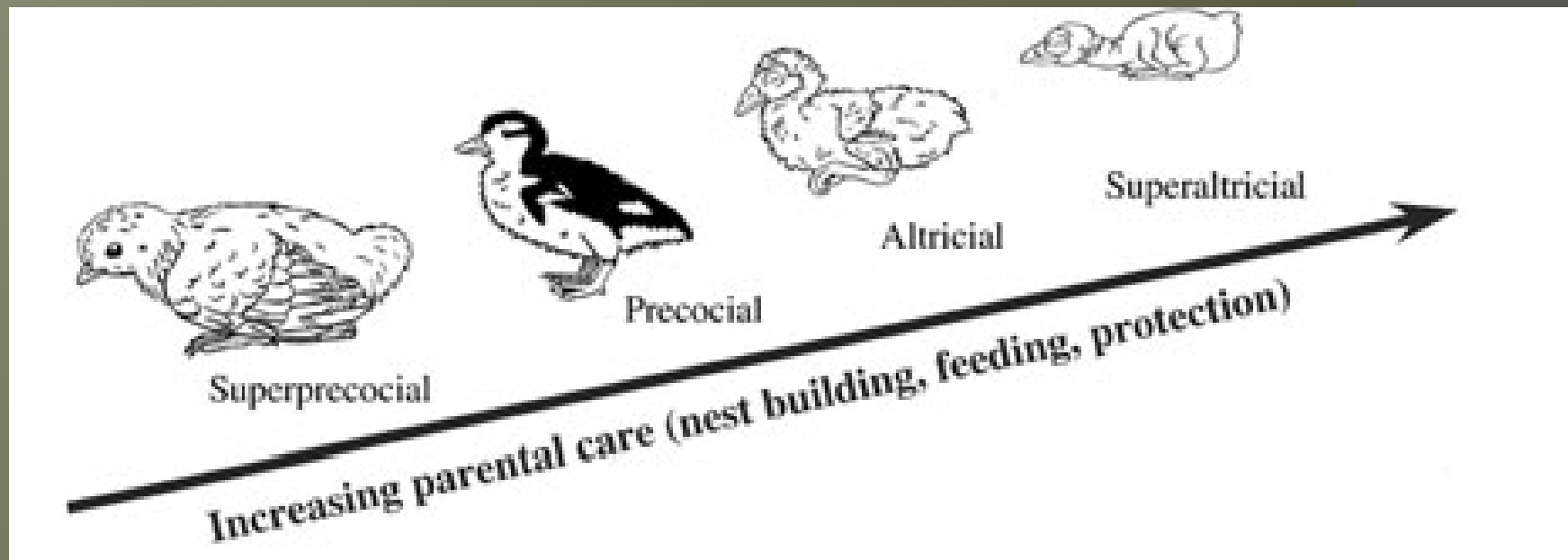
Precocial species
(less care; duckling...)

vs.

Altricial species
(helpless young;
songbirds....)



2. Precocial species provide less/ no care, parents less likely to recognize offspring



When parents (solitary, territorial specie)
fail to recognize offspring:
Some take advantage of it.....



Intra-specific
Brood parasitism

Wood ducks
(egg-dumping)
parasitize neighbors



When parents fail to recognize offspring:
Some take advantage of it.....



Inter-specific
brood-parasitism

European cuckoos
parasitize other
bird species

Inter-specific brood parasitism

Brown-headed cowbirds (parasitize 216 host species)

Host parents fail to recognize parasitic cowbird young



Host-parents sit on whatever eggs in their nest
fail to recognize their own.....



Parasitic cowbird's strategies:

1. Hatch earlier than host young
2. Grow faster than host young
3. Parent cowbirds revenge if host parents don't sit on it.



Interspecific brood parasitism

Brown-headed cowbirds (parasitize 216 host species)



Parental care

1. Costs and benefits of parental care
2. Sexual conflicts in parental care
3. Parent-offspring recognition
4. Parent-offspring conflicts

Parent-offspring conflicts

Parent's best interest:

care as many healthy offspring
as possible: lifetime investment.

Strategies: a few well-fed offspring
or many less healthy offspring?
- depending on resource limit

Parent – offspring conflicts

Offspring's best interest:

maximize each individual's needs,
at the cost of parents or/ and
other siblings' survival.

Parent-offspring conflicts between **nestlings** and parents



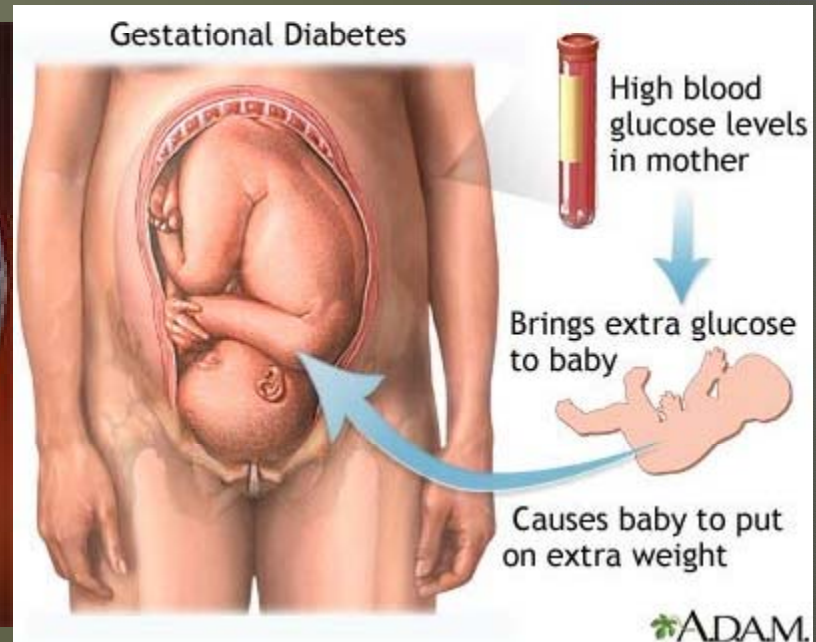
Food begging call as signal for hunger;
but also a manipulative tool

Parent-offspring conflicts between **infants** and parents



Crying signals infant's need,
But also can be used as manipulative tool

Parent-offspring conflicts between **fetuses** and **mom**



Gestational diabetes...
(what is the cause?)

Parent-offspring conflicts

Infanticide



Lions and monkeys:
infanticide by males



Understand species-specific natural history is essential to
understand the evolution of animal behavior

Parent-offspring conflicts

Infanticide



killed by females

Polyandrous jacanas

Parent-offspring conflicts

Infanticide



Phoebes:

killed by males
took over
a territory

Why infanticide?

1. Sexual selection hypothesis,

infanticidal males will gain a reproductive advantage provided that only **unrelated infants** are killed and that the males increase their chances of siring the next infants.

2. Social pathology hypothesis,

infanticide as a result of crowded living conditions and not providing any advantage, regardless of **relatedness**.

How to test these two hypotheses?

Infanticide in lions/ monkeys



killed by males



Support the “sexual selection” hypothesis

Why male lions have infanticide?

1. When a new coming, alpha male take over the female group (pride).
2. A strategy to force females sexually receptive; females give birth every 1-2 years.
3. Dominant α -males have short time-window to control the pride → have their own offspring asap.

A cost to females, benefit to males

Parent-offspring conflicts

Infanticide in humans, why?



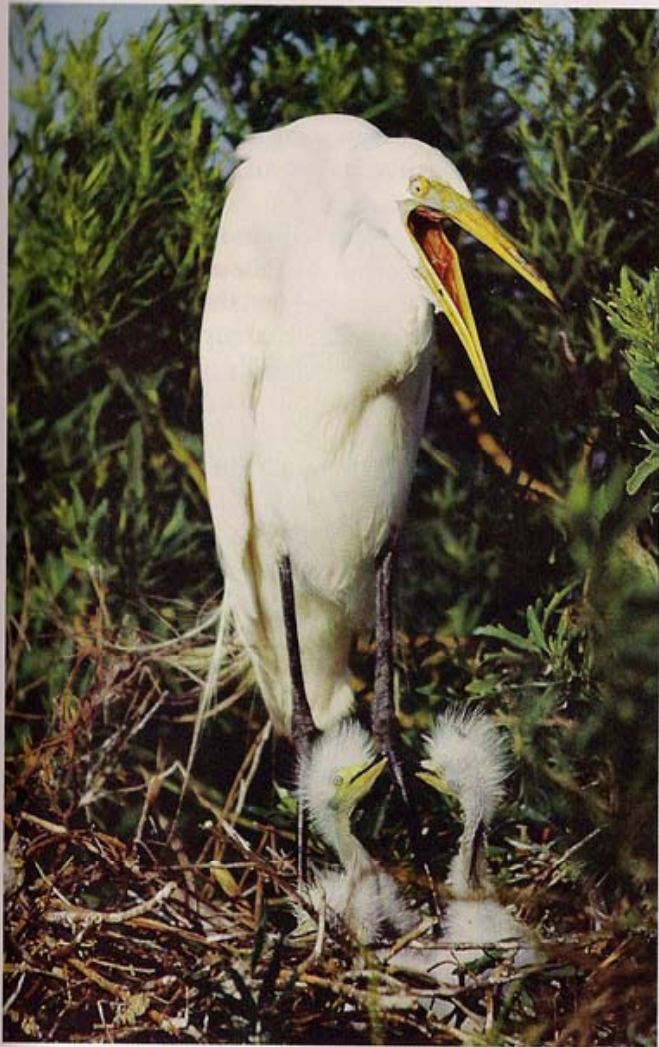
Sibling rivalry

each sibling wants to maximize its benefit



Sibling rivalry

Siblicide



Sibling rivalry

Siblicide



Siblicide in Booby

Older one kills
the younger one

Older one has
higher level of
testosterone

Sibling rivalry

Bigger sibling
repels the smaller one
Parents have no
interruption



Neighbor adults kill it.



Black eagle siblicide



Sibling rivalry

Siblicide



In Spotted hyena,
First one kills the second pup

Older one has higher
testosterone level than
the younger one

Why sibling rivalry? (Siblicide)

Limited food provided from parents

- Compete for food
- Compete for parent's feeding



Figure 5. Five characteristics are common to virtually all siblicidal birds (*from top left to bottom right*): competition for food, provision of food to the nestlings in small units, weaponry, competitive disparities between siblings and spatial confinement. Four of the traits are considered essential preconditions for the evolution of sibling aggression, whereas competitive disparities between siblings may be a consequence rather than a cause of siblicidal behavior.

Sibling rivalry in humans



King Lear --Shakespeare

What exactly do parents provide?

Food,

Home,

Protection (from predator)

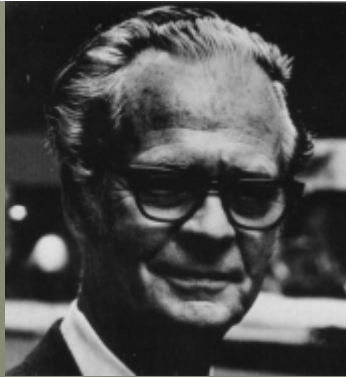
Skills to survive (tool-making, foraging)

Love??

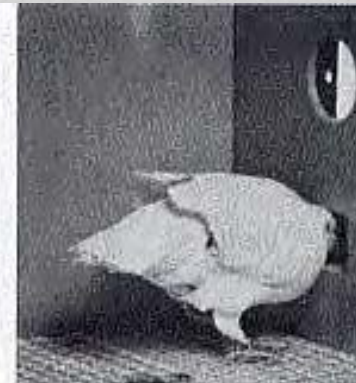
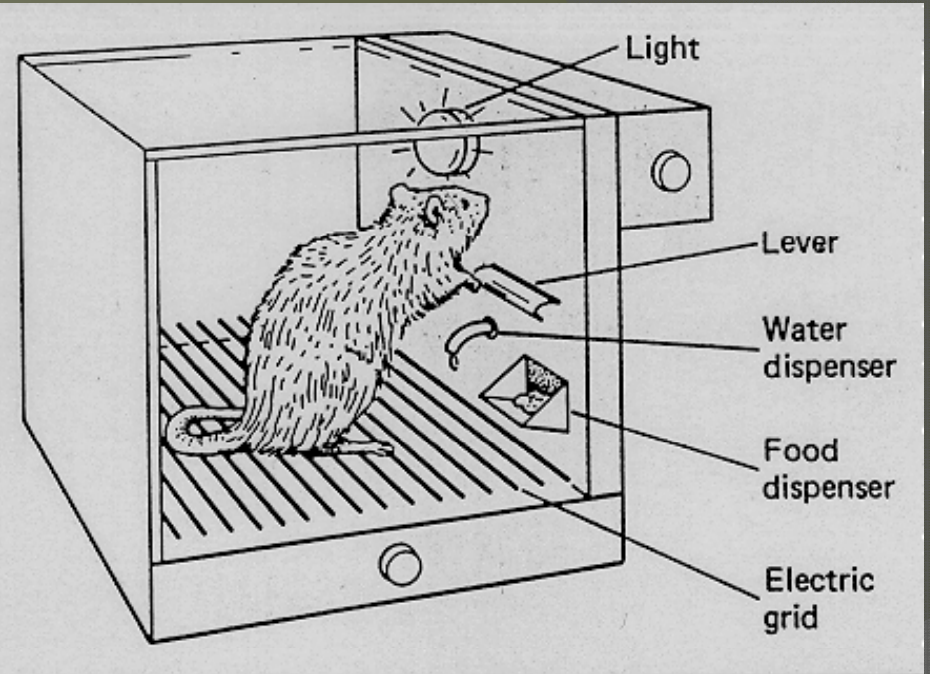
In operant conditioning:

Behaviors can be trained (learned) by providing reward or punishment, so is parenting (teaching) offspring?





Skinner Box



Skinner Box for humans?



Can operant conditioning apply to parental care?

Is **love** or **attachment** really important?

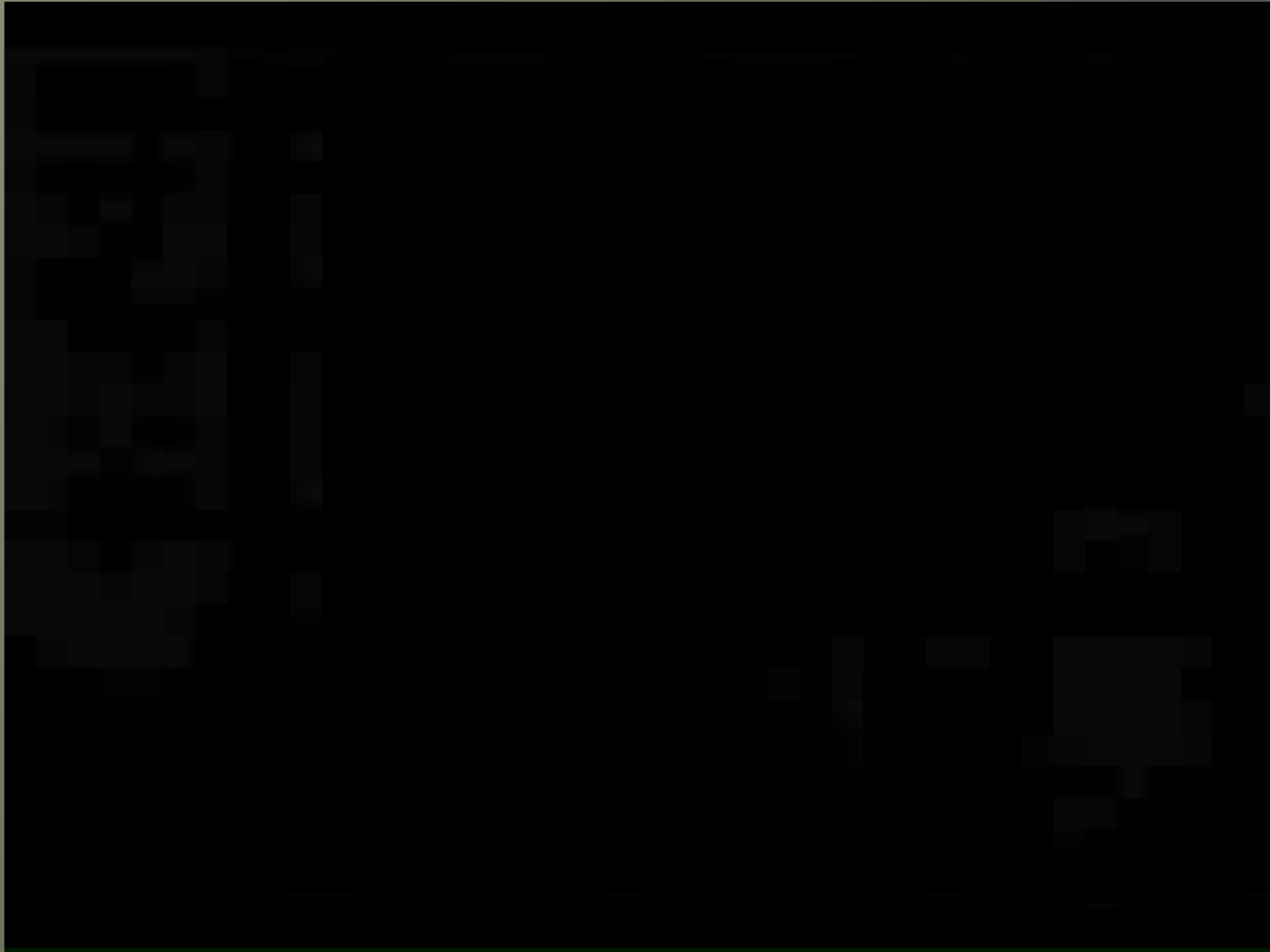
Harry Harlow
~1950s

Test the idea of
Infant-mother attachment

~ according to Skinner,
infants clung to mom
because of food reward



Harry Harlow's experiment I:



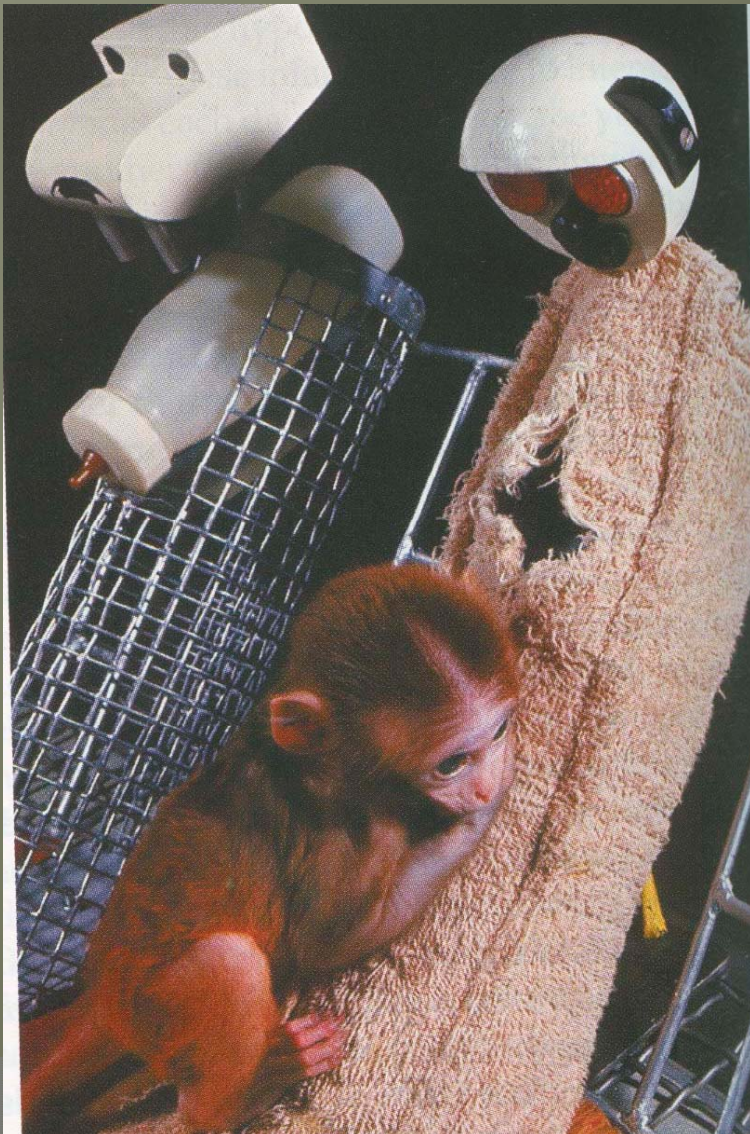
www.youtube.com/watch?v=KlfOecrr6kl

Harry Harlow's experiment II: fear response



<http://www.youtube.com/watch?v=fg9QCeA4FJs&feature=related>

What is missing here?
(what else mom can provide)



As these experimental monkeys grew up: **depression**
stressed
socially awkward



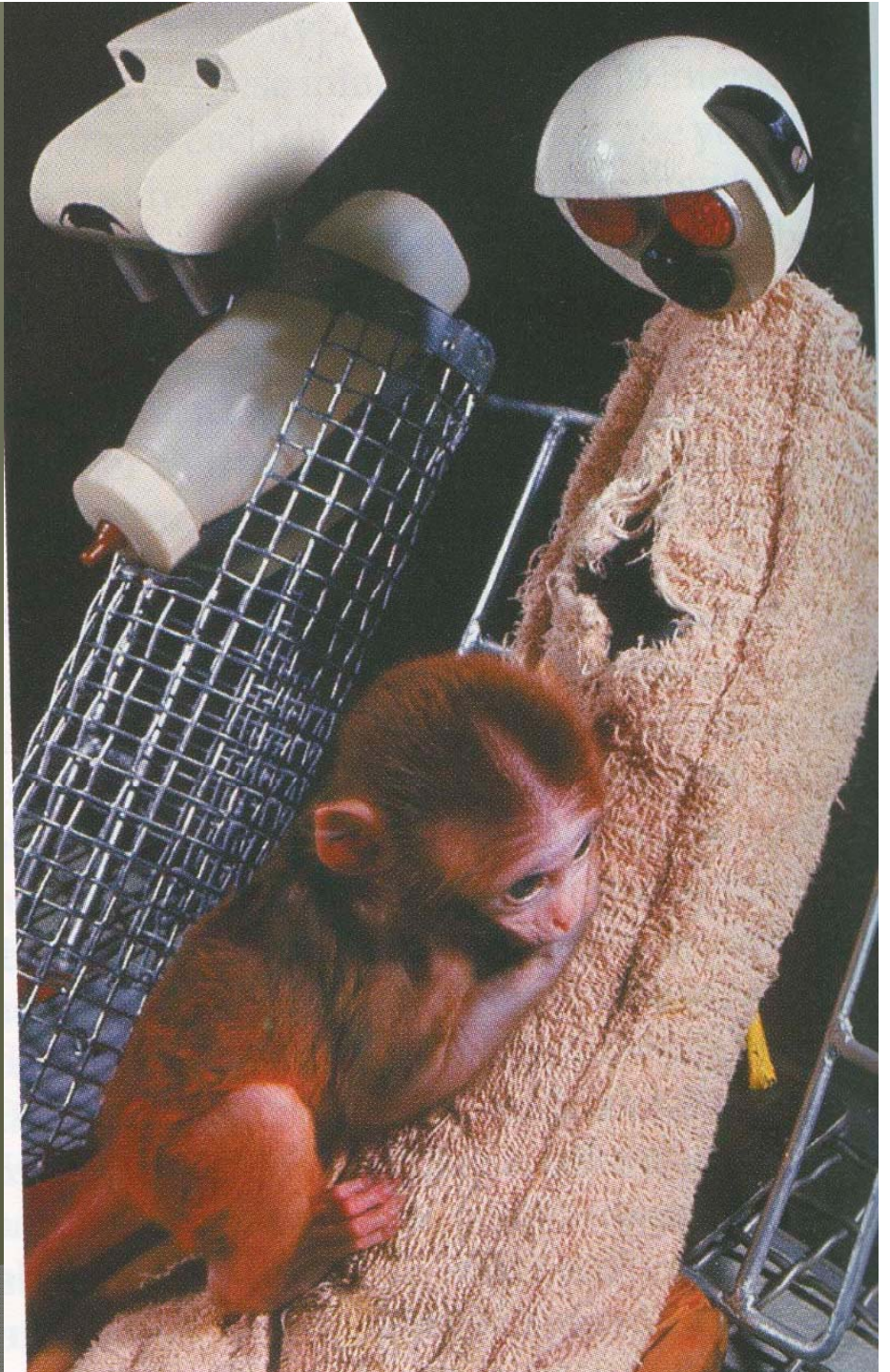
What happened when these
monkeys became mothers?
(motherless mothers)

-- neglectful
-- abusive

toward their own infants
over generations

Neglect begets neglect.

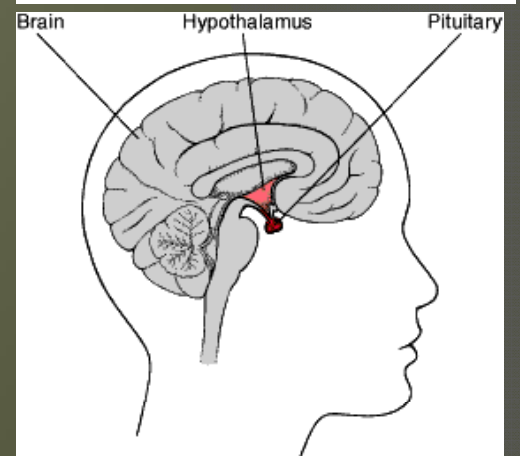
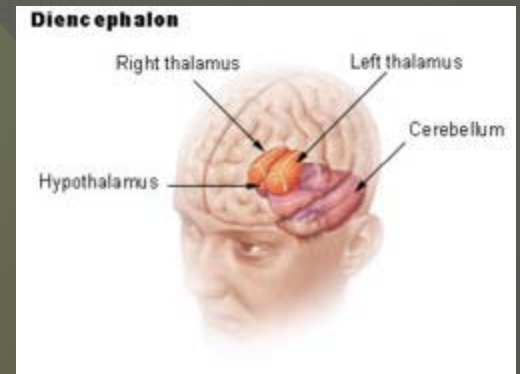
Abuse begets abuse



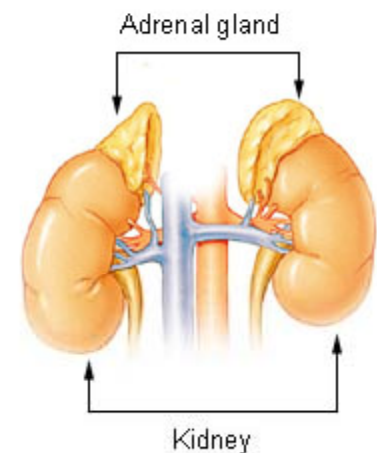
Stress response....

Hypothalamic-pituitary-adrenal

is a complex set of direct influences and feedback interactions among the hypothalamus, the pituitary gland (a pea-shaped structure located below the hypothalamus), and the adrenal glands (small, conical organs on top of the kidneys). The interactions among these organs constitute the HPA axis, a major part of the neuroendocrine system that controls reactions to stress and regulates many body processes.



Adrenal Gland



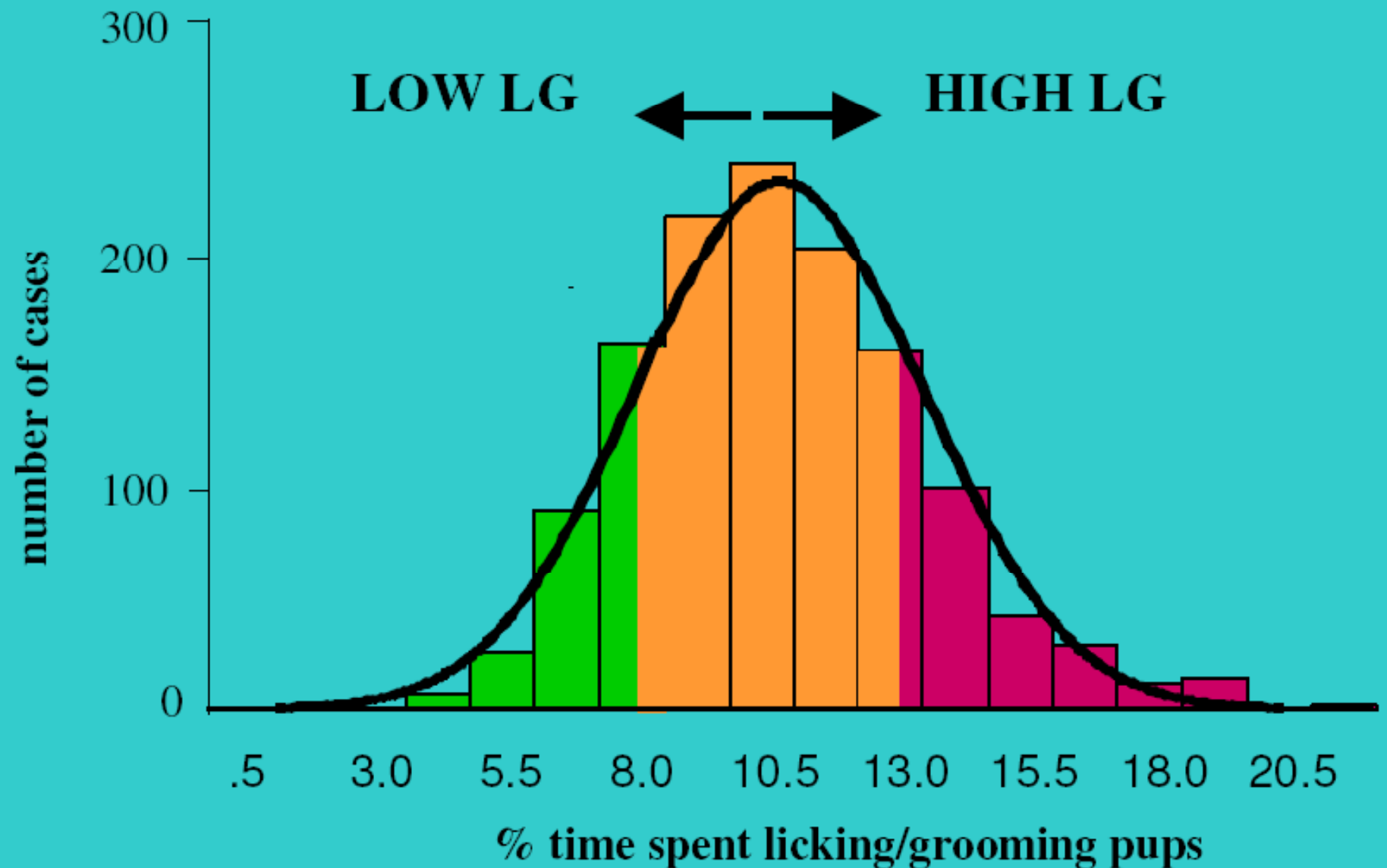
When a mother-to-be is stressed, she produces more cortisol (stress hormone) than she otherwise would. Some of this cortisol is transmitted to the fetus through the placenta. – the elevated cortisol levels experienced by the fetus induces permanent changes in the response to stress: they makes it more sensitive and hyperresponsive to stressful events. predispose to stress-related problems: anxiety disorder, depression, substance abuse, schizophrenia, PTSD.

Parental care in Rats:

Mom: licking and grooming the pups



Frequency Distribution of Maternal Licking & Grooming of Dams (cummulative)



Natural Variations in
Maternal Care



Individual Differences in
Stress Response



Risk of
Psychopathology
(depression, anxiety)

Norway rats,

Offspring of high LG mothers

- less fearful, better stress response
- when grow up, high LG to their pups

Offspring of low LG mothers

- more fearful, worse stress response
- when grow up, low LG to their pups

Fearful mom → fearful offspring

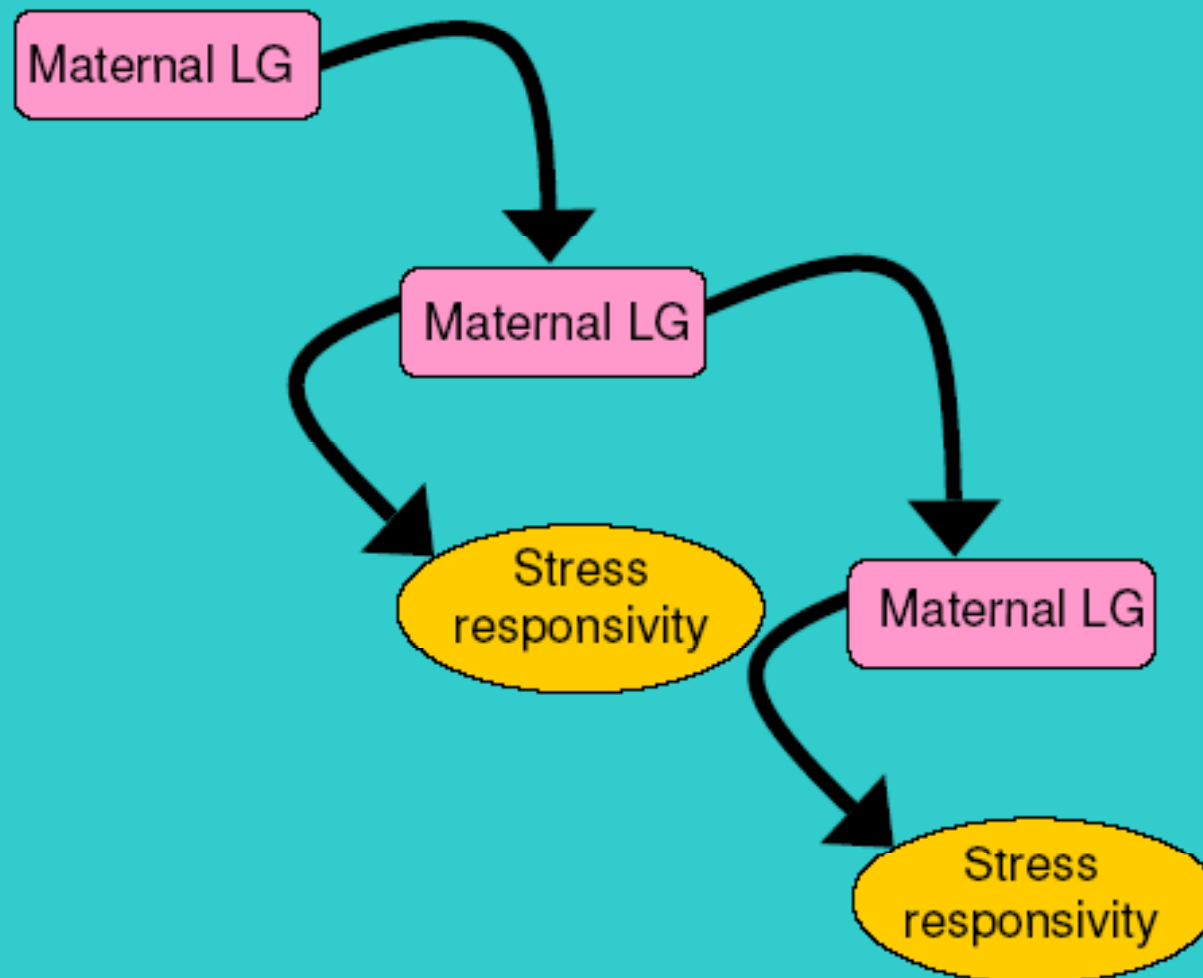
High licking/grooming (LG) mom and their offspring have more GR (Glucocorticoid receptor) and more SR (Serotonin receptor) in their brain.

-- More GR and SR, better stress response.

-- **High** LG mom/infants have **more** GR/ SR in the brain less fear to novelty; better stress response.

-- **Low** LG mom/ infants have **less** GR/ SR in the brain.

Transmission of maternal care and stress responsivity across generations



Champagne & Curley, *Current Opinion in Neurobiology*, 2005

Nongenomic Transmission Across Generations of Maternal Behavior and Stress Responses in the Rat

Darlene Francis, Josie Diorio, Dong Liu, Michael J. Meaney*

Observation: Individual differences in personality traits (stress response; bold/ shy) appear to be transmitted from parents to offspring.

Hypothesis #1: Personality traits are transmitted from genetic mechanisms (genomic transmission)

Hypothesis #2: Personality traits are transmitted through non-genomic mechanisms: parental behavior influence development of personality.

How do we determine if maternal care behavior is genetically or non-genetically transmitted?

Cross-fostering experiment

Mothers
High L-G
Less fear



Offspring
High L-G
Less fear



Offspring
High L-G
Less fear

Mothers
Low L-G
More fear



Offspring
Low L-G
More fear



Offspring
Low L-G
More fear



Next
generation



Next
generation

Mothers
High L-G
Less fear



Offspring
of high LG
mom

Mothers
Low L-G
More fear



Offspring
of low LG
mom



Switch the pups!

Mothers
High L-G
Less fear



Offspring
of low LG
mom

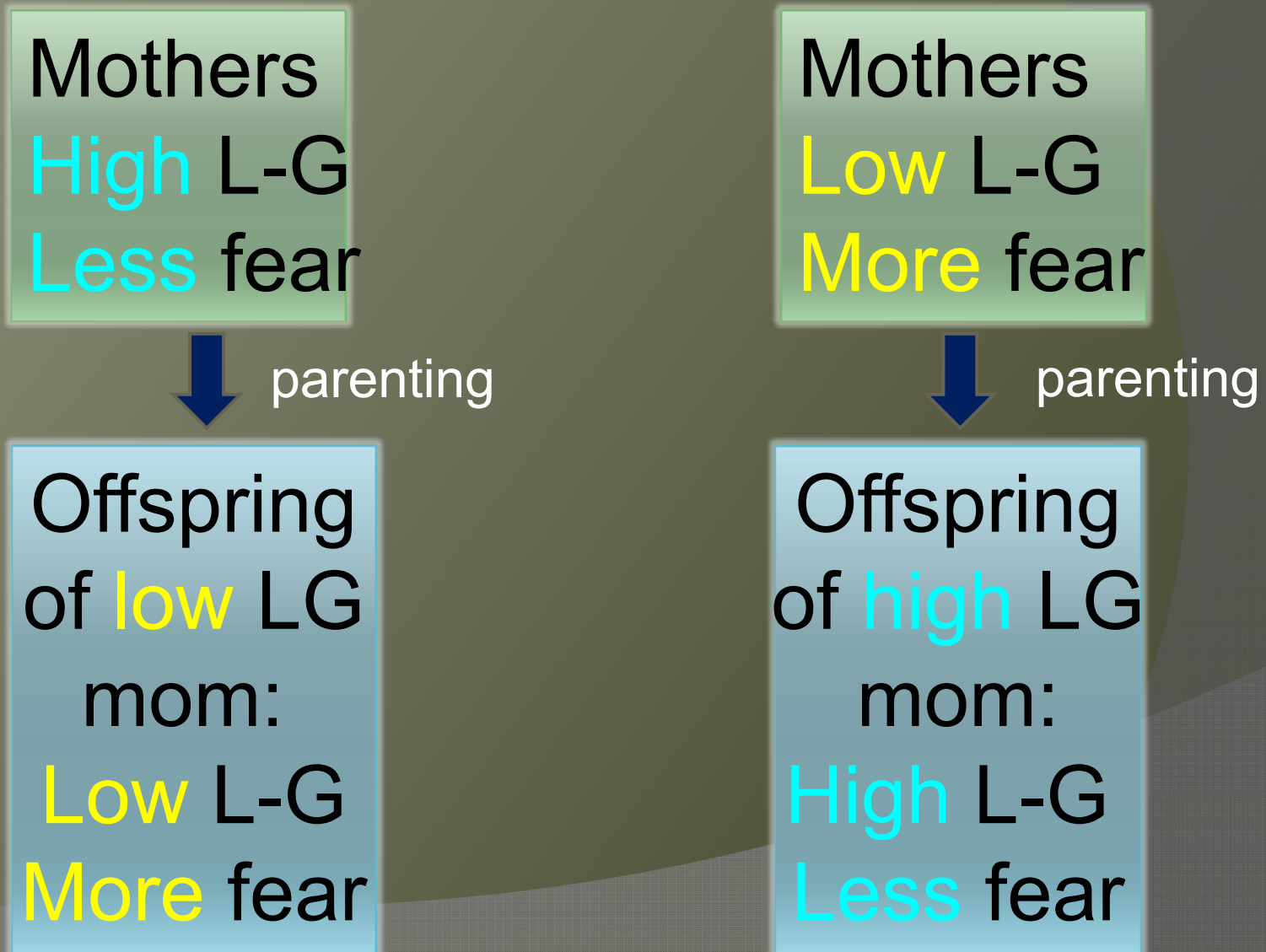


Mothers
Low L-G
More fear

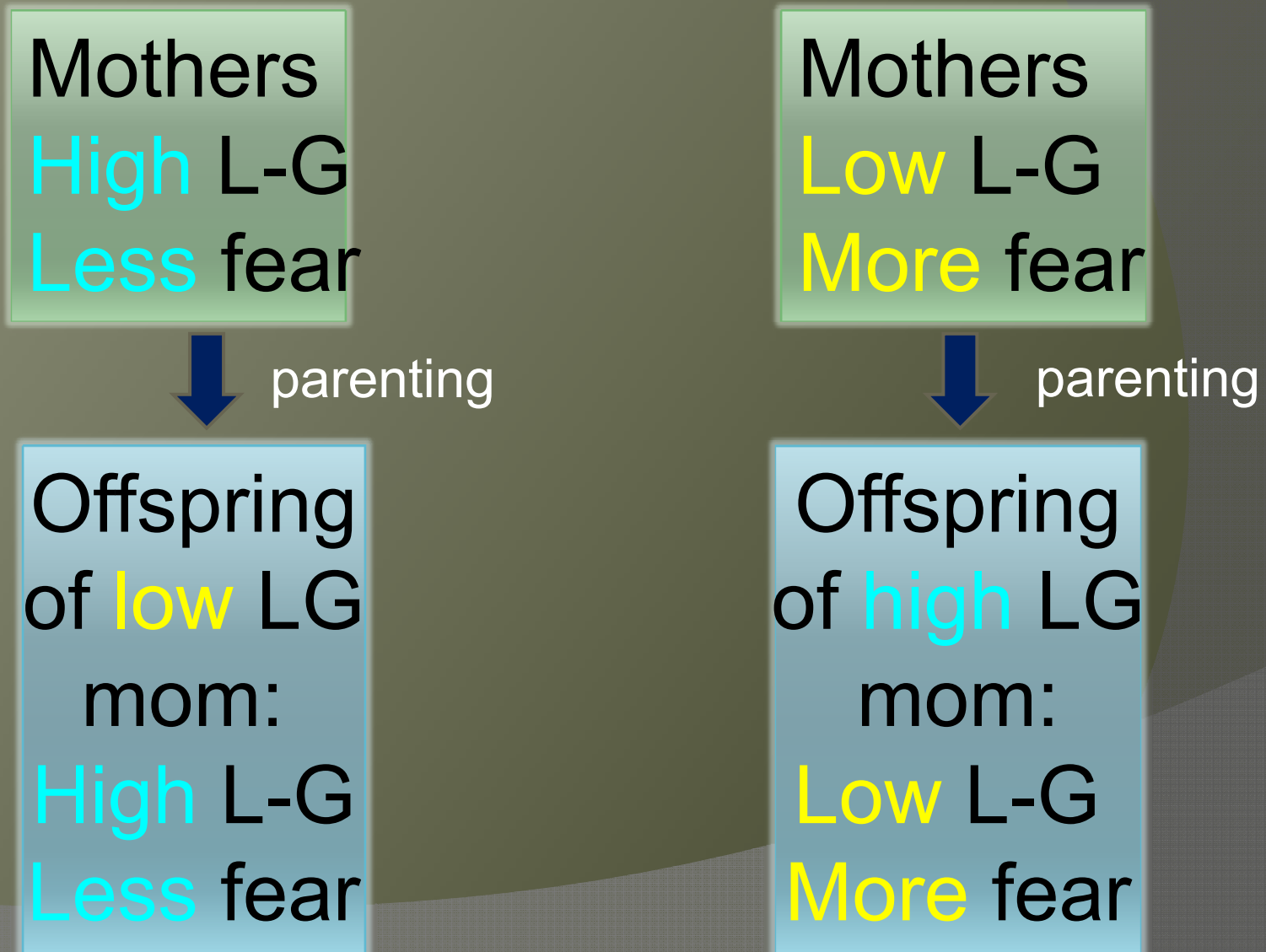


Offspring
of high LG
mom

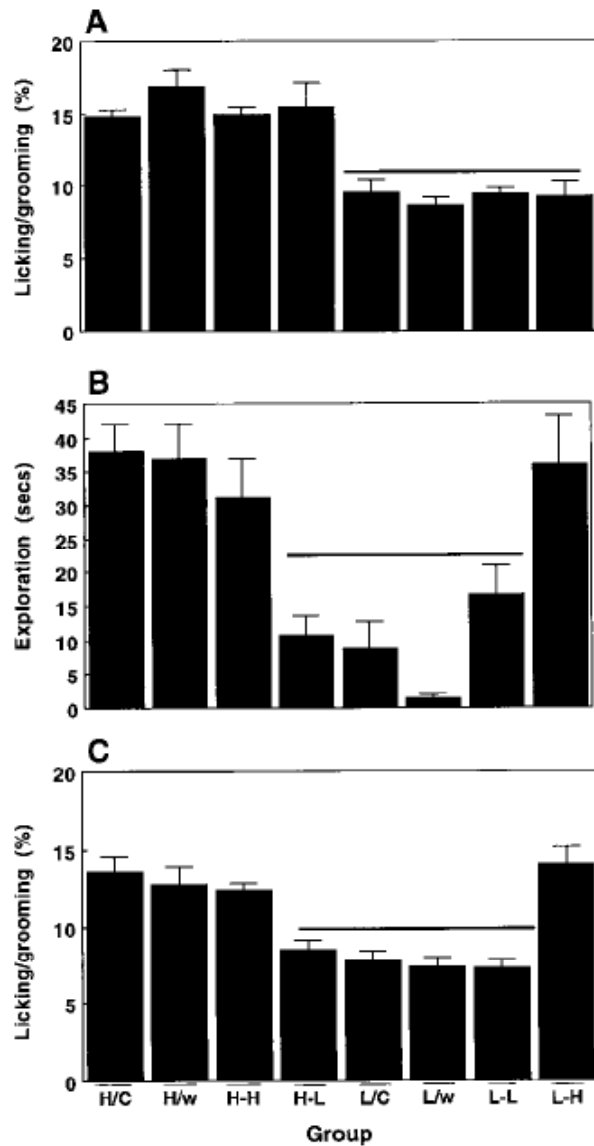
Hypothesis 1: if behavior is **genetically** transmitted, offspring-switching would not affect offspring behavior.



Hypothesis 2: if it is **maternal-behavior** transmitted, offspring-switching would affect offspring's behavior.



Results: Maternal care behavior transmits to the next generation through non-genomic mechanisms.

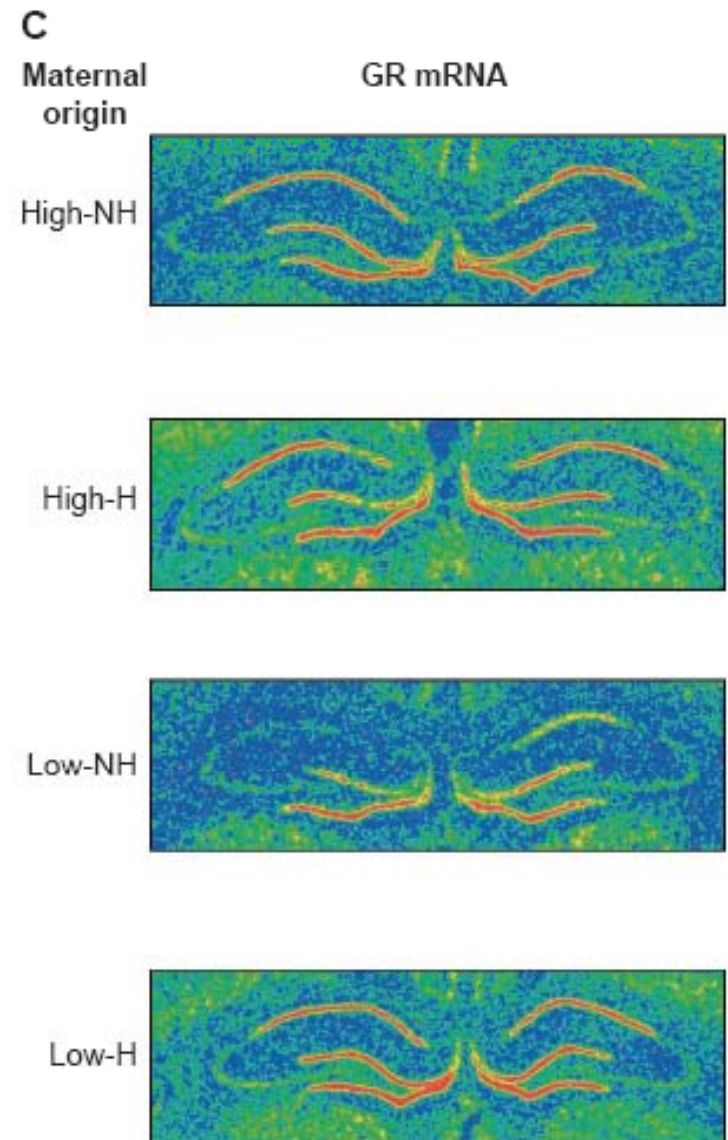
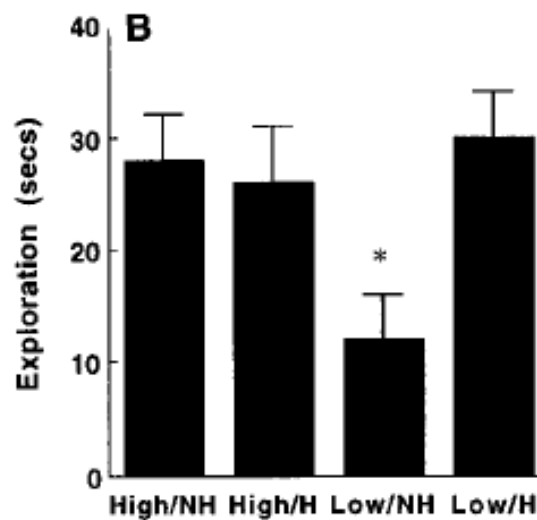
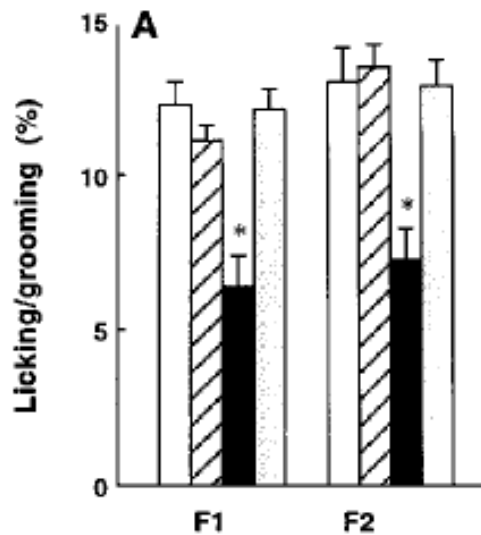


H: high licking/ grooming

L: low licking/ grooming

C: control

Results: Maternal care behavior transmits to the next generation through non-genomic mechanisms.
affect GR expression level
→ and fear response



The mechanisms...

How does mom's licking and grooming induce different stress response, and pass on the offspring?

How does an event (maternal behavior) occurring so early in life have a long-term impact on behavior?

Epigenetic modifications to DNA

What is epigenetics?

Heritable changes in gene expression caused by mechanisms other than changes in the underlying DNA sequence.

Examples of such changes might be **DNA methylation** or histone modification, both of which serve to **suppress gene expression** without altering the sequence of the silenced genes.

DNA contains 2 sources of information:

1) The DNA sequence

(CATTGGATTCCGGA)

GENOME



Generates
proteins

2) The structure of DNA

EPIGENOME



Serves as an
“on/off”
switch for gene
expression

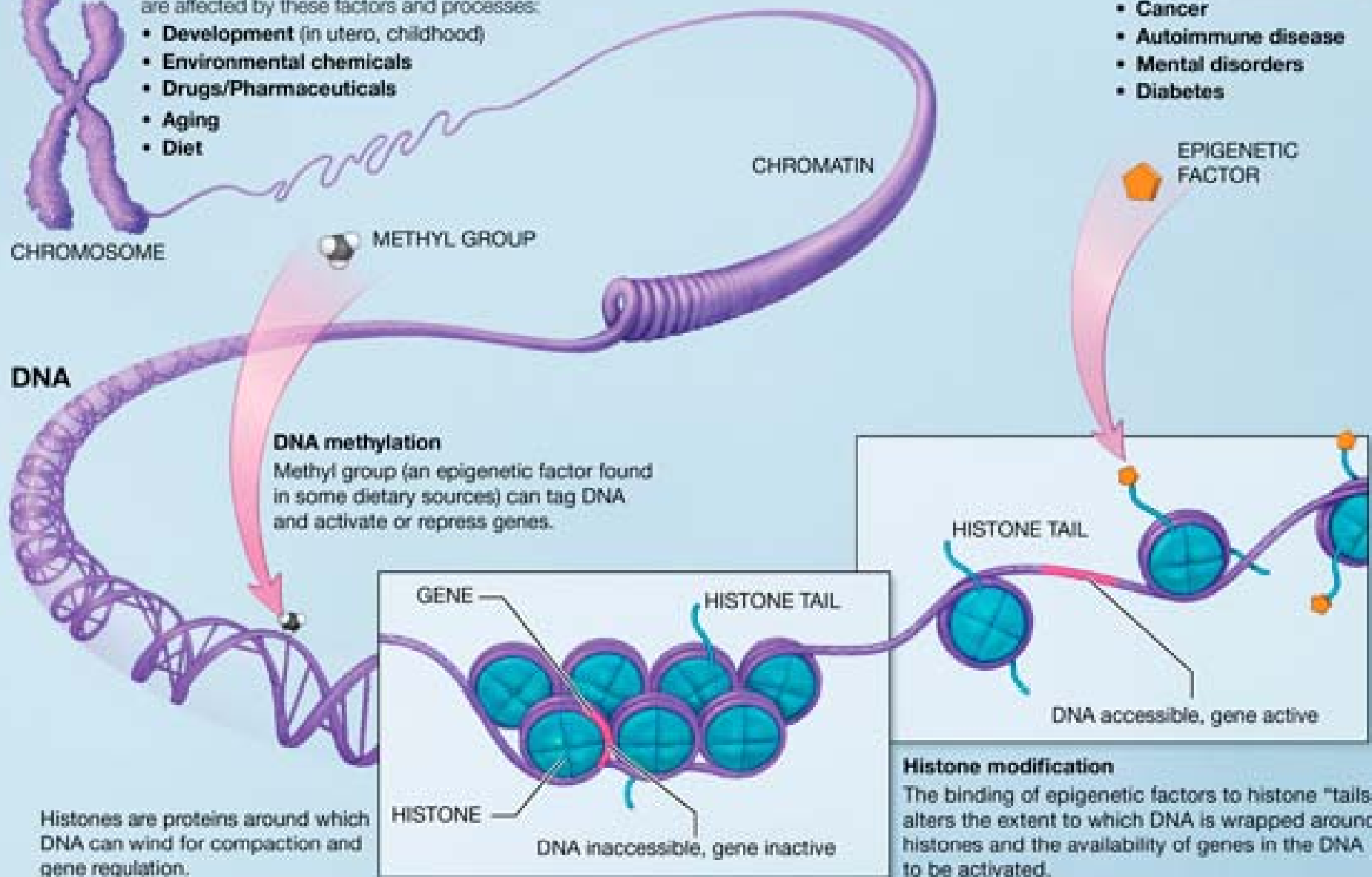
EPIGENETIC MECHANISMS

are affected by these factors and processes:

- Development (in utero, childhood)
- Environmental chemicals
- Drugs/Pharmaceuticals
- Aging
- Diet

HEALTH ENDPOINTS

- Cancer
- Autoimmune disease
- Mental disorders
- Diabetes



Epigenetic modification of DNA

GR Methylation in Response to Rearing Environment

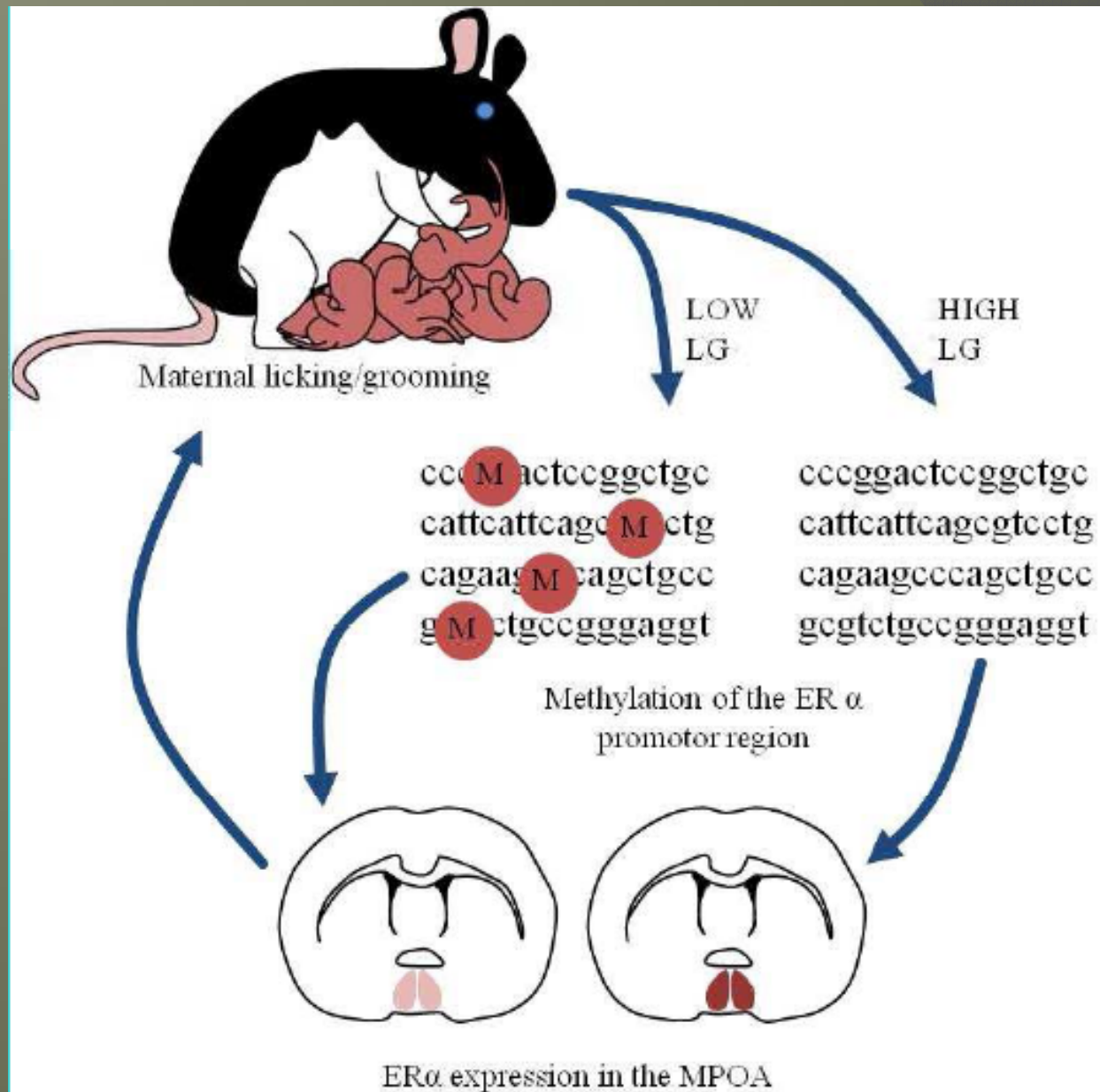
Offspring reared by Low
LG Dam

ccccctctgctagtgtgacacactt **M**
Maactc **M**cagttggcggg**cgcgg**
accacccctgcgggctctgc **M**gctgg
ctgtcaccct **M**ggggctctggctgc
Macccaegggcgggctc**c**gag**c**
gtccaagcc **M**gagtggg **M**ggg
gcg ggaggg agcctggg agaa

Offspring reared by High
LG Dam

ccccctctgctagtgtgacacactt**cgc**
gcaactc**cgc**cagttggcggg**cgcgg**
accacccctgcgggctctgc **M**gctgg
ctgtcacc **M**ggggctctggctgc
cgacccaegggcgggctc**c**gag**c**
gtccaagcc**t**ggagtggg**cgggg**
gcg ggaggg agcctggg agaa

Same DNA sequence, but different extent of methylation
→ different expression of GR → different fear responses





Maternal Licking/grooming

LOW LG

HIGH LG

Increased GR
methylation

Decreased GR
methylation

Decreased GR
expression

Increased GR
expression

Increased stress
response

Decreased
stress response

Low LG/ high LG moms have the same GR gene (DNA sequence), the difference is the methylation of GR gene → high LG pups express and produce more GR → better stress response.

Epigenetic regulation of gene
-- methylation/ demethylation of genes regulate protein production



Nazca booby

First field study shows wild animals (booby) have the same conclusion:
abusive mom has abusive offspring.....



Nat Neurosci. 2009 March ; 12(3): 342–348. doi:10.1038/nn.2270.

Epigenetic regulation of the glucocorticoid receptor in human brain associates with childhood abuse

Abstract

Maternal care influences hypothalamic-pituitary-adrenal (HPA) function in the rat through epigenetic programming of glucocorticoid receptor expression. In humans, childhood abuse alters HPA stress responses and increases the risk of suicide. We examined epigenetic differences in a neuron-specific glucocorticoid receptor (*NR3C1*) promoter between postmortem hippocampus obtained from suicide victims with a history of childhood abuse and those from either suicide victims with no childhood abuse or controls. We found decreased levels of glucocorticoid receptor mRNA, as well as mRNA transcripts bearing the glucocorticoid receptor 1_F splice variant and increased cytosine methylation of an *NR3C1* promoter. Patch-methylated *NR3C1* promoter constructs that mimicked the methylation state in samples from abused suicide victims showed decreased NGFI-A transcription factor binding and NGFI-A-inducible gene transcription. These findings translate previous results from rat to humans and suggest a common effect of parental care on the epigenetic regulation of hippocampal glucocorticoid receptor expression.

